2D and 3D Modeling of the Stratigraphic Sequences at the Adriatic and Rhone Continental Margins

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LONG-TERM GOALS

My goal within the EuroSTRATAFORM program is *to understand the creation of the preserved stratigraphic record on continental shelves and slopes as the product of physical processes acting with spatial and temporal heterogeneities.* I have been using numerical models to provide insight into the formation and preservation of stratigraphic sequences at margins. My goal has been to obtain a quantitative understanding of the interactions of environmental parameters and their influence on stratal architecture and facies distribution. I wish to be able decipher the stratigraphy on margins to read the geologic record of the past and predict future stratigraphy.

OBJECTIVES

EuroSTRATAFORM represents an opportunity to extend the STRATAFORM approach to test model applicability at new margins and to expand the capabilities of our products. The Rhône and Adriatic margins are similar to the earlier field areas in that they are mid-latitude clastic margins, but the stratigraphy is much more affected by the 3D geometry of the basins. The forcing provided by these boundary conditions provide a challenge, but are also necessary for modeling realistic systems. My aim is to quantitatively determine the system response of margins to different forcing functions sufficiently to be able to both predict stratigraphy and invert observed sequence architecture for geologic history.

APPROACH

I have used numerical models as a tool to provide insight into the formation and preservation of stratigraphic sequences at continental margins. To study these margins I will apply a multi-pronged approach. 1) Together with Italian and French colleagues, I will modify and apply our existing 2D stratigraphic models to serial sections of the two EuroSTRATAFORM margins. This will test the portability of the models. It will also aid in evaluating the relative along- and across-strike transport and their influences on sequence architecture. 2) Chris Paola, John Swenson, and a postdoc, Juan Fedele, and I will jointly develop a 3-D sequence stratigraphic model, with numerical assistance from Marc Spiegelman. Together, we will extend our time-averaged, moving-boundary model for continental-margin sedimentation with its coupling of multiple transport regimes from 2-D to 3-D. The advantage of this modeling approach is that it allows for a systematic exploration of the margin's response to variations in sea level, sediment supply, tectonic subsidence, and wave climate over longer timescales. 3) I will also make limited use of backstripping techniques to recover estimates of tectonic subsidence and/or initial morphologies of paleosurfaces that are necessary for the forward modeling.

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WORK COMPLETED

The 2D model developed during STRATAFORM (Steckler, 1999; Steckler et al., 2001) has been modified in order to apply it to the Adriatic field area. The primary changes have been to include along-strike transport of offshore sediments and improvements in variations of the sediment flux with sea level. The 2D modeling is focusing on the Gargano Peninsula region where a succession of four depositional sequences (e.g., Fig. 1) mainly composed of regressive deposits have been mapped by Ridente and Trincardi (2002). Together, we have chosen a series of 10 seismic profiles along the Gargano structure for modeling (Fig. 1). At present, one of the northernmost profiles, which is relatively unaffected by the tectonics of the peninsula has been modeled.

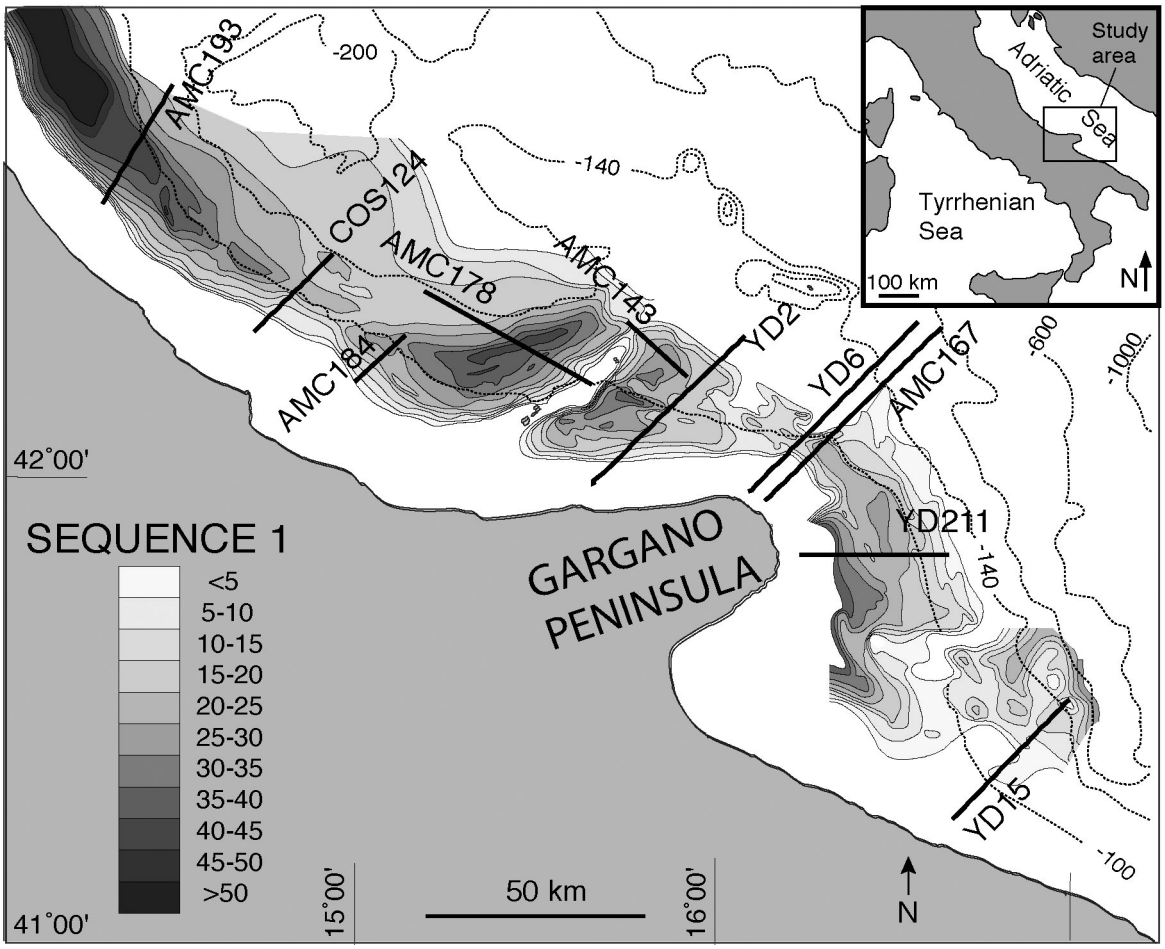

Figure 1. Map of Gargano Peninsula region with bathymetric contours. The thickness of Sequence 1 is indicated by shades of gray. Heavy lines indicate the positions of the 10 seismic profiles selected for modeling. An inset map shows the position of the Gargano Peninsula region along the Adriatic coast of Italy.

Led by John Swenson, an initial version of the 3D stratigraphic model has been developed (Swenson et al., 2003. I am working on developing a 3D variable rigidity flexure module to be incorporated into the code.

RESULTS

A preliminary model has been developed that reproduces the main features of the sequences north of the Gargano Peninsula using line COS124 (Fig. 1, 2). This model will then be used as a basis for the sections farther south that have been affected by the tectonics around the Gargano Peninsula. In order to reproduce the geometry of the sequence, the model required uplift increasing towards land. The rates used are similar to estimates reported in the literature (e.g., Mastronuzzi and Sansò, 2002). An important requirement was a sediment flux that varied with sea level. This reflects the changes in sediment pathways. During sea level highstands, the currents in the Adriatic transport sediment from the Po and Apennine Rivers along the Italian coast to the Gargano region (Cattaneo et al., 2003). During sea level lowstands, the Po, joined by the Apennine Rivers as tributaries, travels down the exposed axis of the Adriatic and debouches into the Mid-Adriatic Deep. During lowtands, little sediment reaches the Gargano region. An unexpected consequence of the sediment fluctuations was that the decreasing flux during sea level falls aids erosion of the previous transgressive deposits. Additional sediment pathway effects during sea level cycles are expected to affect the sections farther south due to the presence of structural highs such as the Tremiti Ridge. In addition, the relative equilibrium slopes of the coastal plain and the shelf ha been found to have a significant effect on the pattern of preservation of the stratigraphy.

IMPACT/APPLICATIONS

Sediment supply is commonly assumed to increase during sea level falls when a larger area is subareally exposed and decrease during sea level rises as surface area is flooded and sediments trapped in estuaries. Along the Adriatic coast, we find the opposite effect occurs due to a combination of the mainly marine, along-strike source of the sediments and the changes in its transport pathways associated with sea level. Since little sediment is supplied from land at the Gargano Peninsula, alterations in its supply from sea level change is unimportant. This alternative sediment supply pattern may be common along margins where sediment transport often has a large along-strike component. At both the Rhone and Eel River margins, sediment is transported along the margin during highstands while the shelf may be sediment starved during lowstands when the Rivers discharge directly into canyon systems.

RELATED PROJECTS

I have been funded by NSF to undertake a 3D backstripping reconstruction of the Gulf of Lions continental margin (Steckler et al., 2003). During the Messinian Salinity Crisis (5.87-5.33 Ma), the Mediterranean was cut off from the world ocean and desiccated. As a result the Gulf of Lions continental was heavily eroded and the margin morphology reduced to a heavily incised seaward dipping ramp (Guennoc et al., 2000). Following the flooding at the end of the Messinian, the margin rebuilt to its present shelf-break morphology. The 60-100 km of progradation during the Plio-Pleistocene provides a stratigraphic record of the establishment and regrowth of the margin. The 3D reconstructions will provide reconstructions of the morphology of the margin for timeslices of interest to EuroSTRATAFORM. The project also involves Greg Mountain and Bill Ryan at Lamont, and Serge Berné of IFREMER Marina Rabineau of IUEM and Christian Gorini of USTL from France.

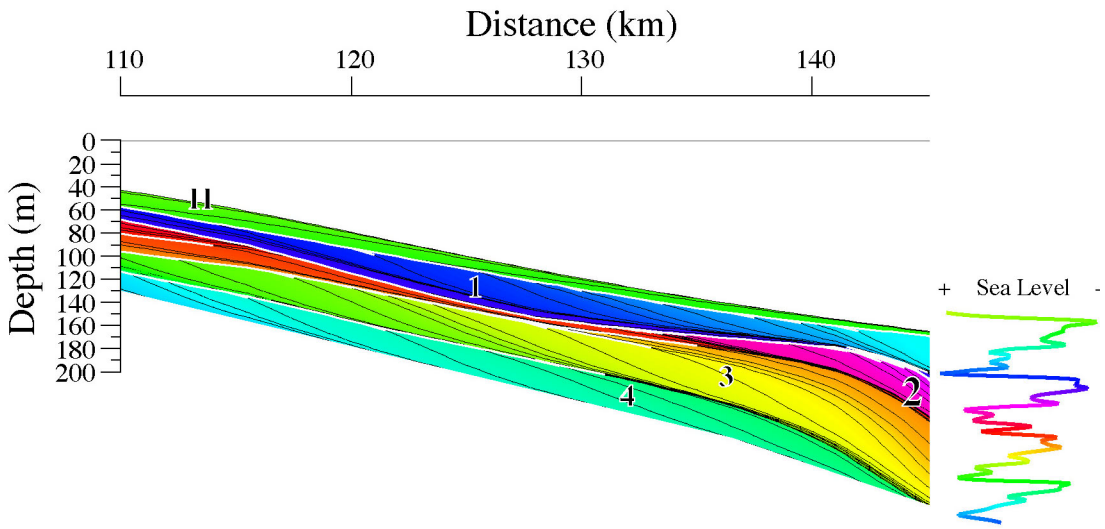

Figure 2. Synthetic stratigraphic section produced by numerical model. Horizontal scale is in kilometers, vertical in meters. Timelines are shown every 5,000 years. Sediments are colored according to their age, as in the sea level curve used in the simulation, shown at the right. Unconformities are drawn in white. The stratigraphy is composed of four regressive sequences, labeled 1-4, capped by Holocene transgressive deposits labeled H. The packages correspond to those observed at the Gargano Peninsula. While regressive sequence 2 pinches out seaward of sequence 3 as observed, there is a red-orange section preserved farter landward that differs from most observed sections. However, this feature is found on line AMC167 (Fig. 1). This may be due to he shape of sea level curve used, based on the Specmap oxygen isostope curve, a need for greater uplift in the landward part of the section, or a tectonic change at this time.

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